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A NEW METHOD TO ESTIMATE MYOELECTRIC MANIFESTATION OF MUSCLE FATIGUE

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Aims

Fatigue may be described as a feeling or sensation of weakness or muscle pain or a decrement of performance, not easily suitable for quantification or measurement. During a muscle contraction, albeit in absence of mechanical manifestations of fatigue, strong modifications in surface EMG signal can occur: the so-called myoelectric manifestations of fatigue. Two main physiological factors are at the origin of the myoelectric manifestations of fatigue: 1) the decrease of the conduction velocity (CV) of motor unit action potentials (MUAP) ("peripheral fatigue" in the following), and 2) the increase of motor unit (MU) synchronization by the central nervous system ("central fatigue" in the following). We suggest quantifying the myoelectric manifestations of muscle fatigue through a two dimensional vector based on two distinct measures of central and peripheral fatigue, instead of using a scalar estimator.

Methods

To separately describe the peripheral and central components of the myoelectric manifestations of fatigue, we investigated the following estimators: 1) mean spectral frequency – MNF, 2) median spectral frequency – MDF, 3) root mean square – RMS, 4) average rectified value – ARV, 5) muscle fibre conduction velocity - CV, 6) percentage of determinism (obtained from recurrence quantification analysis) – %DET , 7) spectral indexes defined as the ratio between the signal spectral moment of order -1 and moments of order k=2÷5 (FI_k), 8) mean frequency of the power spectrum density estimated by autoregressive analysis – MNFAR, 9) mean frequency of the power spectrum density estimated by Choi-Williams time-frequency representation – MNFCWD, 10) mean frequency of the power spectrum density estimated by continuous wavelet transform – MNFCWT, 11) fractal dimension – FD (the new parameter herein proposed for EMG fatigue estimation).

The estimators were tested with a set of 20 synthetic signals 20s long using a model with a planar description of the volume conductor. The simulated contraction level was 80% MVC. Each signal presented an increasing level of synchronization (from 0 to 20% of synchronized MUs) and a decreasing CV (-0.1 m/s^2). The estimators were calculated on epochs of 0.5s. The best estimators were chosen by the criterion of being selective to one of the two physiological factors inducing myoelectric manifestation of fatigue, i.e. either to peripheral or to central fatigue.

Results

It was found that CV estimation is uncorrelated to the level of simulated synchronism (as expected), being the most promising method for the estimation of peripheral fatigue. On the contrary FD was the estimator least affected by CV changes and most related to the level of synchronism, being the most promising estimator of this manifestation of central fatigue.

Conclusions

The availability of two independent estimators of central and peripheral fatigue provides new insights into myoelectric manifestation of fatigue describing the whole phenomenon and assessing, by means of a two dimensional vector (CV, FD), the relative role of both central and peripheral fatigue.

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